BEFORE THE STATE OF WASHINGTON
ENERGY FACILITY SITE EVALUATION COUNCIL

IN RE APPLICATION NO. 96-1 OLYMPIC PIPE LINE COMPANY: CROSS CASCADE PIPELINE PROJECT	))))))

EXHIBIT _____ (MPM-T)

REBUTTAL TESTIMONY OF MARK P. MOLINARI

ISSUE: EARTHQUAKES AND SEISMICITY; EROSION

SPONSOR: OLYMPIC PIPE LINE COMPANY

Q. State your name.

A. Mark P. Molinari
2025 1st Ave. Suite 500
Seattle, Washington, 98121

Q. Where are you employed and what is your position?

A. I am an Associate Geologist at Dames & Moore.

Q. Summarize your professional experience.

A. I have 16 years experience assessing geologic and seismic hazards. I provide senior level technical services and project management for engineering geology and geologic and seismic hazard investigations, hydrogeologic studies, and environmental impact studies/reports. My experience includes performing geologic and seismic hazards evaluation; development of seismic source models for probabilistic and deterministic seismic hazards analyses for onshore and offshore engineered structures; and evaluation of landslides, subsidence, liquefaction and surface fault displacement potential. A more detailed list of projects that I have worked on is attached hereto as Exhibit MPM-1.

Q. Have you published in your field?

A. A list of publications is included in my attached resume (MPM-1).

Q. What is your educational background?

A. M.S., 1984, Geology, University of Nevada, Reno; B.A., 1980, Geology, University of California, Santa Barbara.

Q. What was your involvement in this project?

A. I assisted in preparing the Revised Application, including reviewing geology for the mass wasting hazard assessment, participating in the aerial and ground surveys, helping to identify sites for field reconnaissance, and performing the seismic assessment for earthquake hazards and faults.

Q. To which prefiled testimony are you responding?

A. I am responding the following testimony regarding earthquakes and seismicity: Timothy Walsh (DNR); Hank Landau (CCA); Kevin Lindsey (CCA); Peter Comenzo (Grant County); Damien Hooper (Grant County); Dee Caputo (Adams County); and Mark Pedersen. I am also responding to the following testimony regarding erosion: Hank Landau (CCA); George Wooten (CCA); Stephen Bottheim (King County); Mark Pedersen (various counties).

EARTHQUAKES AND SEISMICITY

Q. What are some of the key factors that are considered in a seismic hazard assessment of a project like the pipeline?

Known and potential seismic sources. These are existing faults that are known or suspected to be capable of generating a moderate to large earthquake, active volcanoes, as well as background seismicity for the relevant area. The sources are identified based on review of geologic studies of soils and rocks extending back thousands of years, and records of historical seismicity. Historical seismic activity is assessed using reported information (*e.g.* published reports, newspapers) on historical earthquakes and instrumentally recorded data from the region. In this region, the historical information extends back to 1833 for large and major earthquakes. The earliest recorded major earthquake (Magnitude 7+) occurred in the North Cascades in 1872 (Noson and others, 1988). For the area covered by the project, the seismic source with the greatest probability of generating a large to major earthquake during the project lifetime is the

Cascadia Subduction Zone (CSZ), an east-dipping fault between the Juan de Fuca and North American tectonic plates. The CSZ extends from the Pacific Ocean floor to 50-60 kilometers beneath Puget Sound.

Estimated magnitude and earthquake recurrence for each source. Magnitude (M) is a measure of earthquake size. It is recorded on various scales, such as the Richter scale, and now more commonly the Moment Magnitude Scale, which is considered to be a more representative measure of the energy released in an earthquake. Recurrence is simply how often earthquakes of a certain magnitude are known or are likely to occur on a fault or other source.

Estimated Peak Ground Acceleration associated with the earthquakes at the level of probability used for the assessment. Peak Ground Acceleration (PGA) is a measure of the maximum acceleration at the ground surface during earthquake associated ground-shaking. PGA at a specific location is a function of several factors including the magnitude of the earthquake, the distance from the earthquake, and the type of soil or rock at the location where the measurement is made. PGA is recorded as a percentage of gravity, *i.e.* the percentage of 1.0 g. PGA can be estimated for a probability of occurrence during a specific time frame. In general, the USGS has estimated that the probable strong ground motions expected during the project lifetime would be greatest in western Washington and significantly diminish as the route extends east. For example, the Application presented PGAs estimated by the U.S. Geological Survey (USGS, 1996) with a 10% probability of occurrence in a 50 year time frame, *i.e.* the estimated PGA that will occur at a location once every 475 years. Using USGS values for this probability, the Application reported that the PGAs for the project range from a high of 0.29g at the western terminus down to 0.08g at the eastern terminus.

Faults that pose a potential surface fault rupture hazard. To the extent the pipeline route crosses faults which are potential seismic sources, consideration is given whether such faults have the potential to generate rupture of the ground surface during the pipeline lifetime. This is assessed by observing surface evidence of displacement of relatively young geologic deposits by a fault, conducting geologic investigations to evaluate the amount and nature of previous ground ruptures, and/or estimating the amount of surface displacement likely to occur on a fault in the event of a large earthquake. This is estimated using empirical relationships between earthquake magnitude and surface fault displacement based on historical earthquakes.

Earthquake induced liquefaction and associated ground failure. Liquefaction is the failure of saturated soils typically during a seismic event. In addition, other ground deformation such as lateral spreads or settlement can occur. This issue is addressed separately in the rebuttal testimony of Conrad Felice.

Q. How will these key factors be considered in the project process?

A. The evaluation of seismic hazards throughout the project process is iterative including the Application, a design phase and a construction phase:

The Application Phase. The Application is intended to identify potential seismic hazards that could impact the proposed pipeline and associated facilities, and describe potential measures that could be used in the design phase to mitigate the potential hazards to an appropriate risk level. The Application included three considerations. First, a route for the pipeline was selected to avoid crossing late Quaternary faults and areas with a high potential for earthquake induced liquefaction and ground deformation to the extent practicable given other siting constraints (e.g. right-of-way, land use, wetlands, etc.). Second, using the factors outlined above, an assessment was made of the seismic hazards likely to be encountered along the route. Third, potential mitigation measures (i.e. reinforced pipe, special trench design, and block valves) that could be used to mitigate the identified hazards were outlined, where appropriate.

The Design Phase. During the design phase, site specific investigations will conducted to further assess areas of potential hazards along the pipeline route. This information will be used to select and design appropriate mitigation measures for the hazards identified. For example, to the extent the pipeline will be crossing faults with the potential for ground rupture, the trench and pipeline will employ special designs developed to resist significant ground deformation. Bellow is an illustration of a special trench design for areas susceptible to reverse slip faults. Exhibit MPM-2 (Nyman p. 172,1996). Similarly, a more detailed seismic analysis will be conducted to develop the seismic criteria for use in the design of the above ground facilities per the applicable codes and standard engineering practice.

The Construction Phase. During the construction phase, the design will be implemented and modifications will be made to the extent necessary if unexpected, adverse conditions are encountered.

1. *<u>Known and potential seismic sources</u>.*

Q. What information was considered to determine known and potential seismic sources?

A. Published and readily available reports and maps on the geology, seismic hazards, and historical seismicity of Washington were obtained and reviewed. Most of these sources were referenced in Sections 2.15.2 and 3.1.4, and listed in Section 1.5.1 of the Application. Other maps and reports were reviewed and used to assess seismic hazards and prepare the Geologic, Topographic, and Mass Wasting Hazard maps but were not listed in these sections. These data sources include: Booth (1990), Reidel (1988), Reidel and Fecht (1994a,b), Reidel and others, (1994), Tolan and Reidel (1989), and Schuster (1994).

2. *<u>Estimated magnitude and earthquake recurrence for each source</u>.*

Q. Walsh contends that for the Cascadia Subduction Zone (CSZ) a magnitude 9, or even 9.2, should be used for design instead of magnitude 8.5. Why is a magnitude of 8.5 reasonable for preparing the Application?

A. At the time the Application was prepared, the predominant opinion among the scientific community assessing earthquake hazards in the Pacific Northwest was that a magnitude of 8.5 was likely the largest earthquake that could occur on the CSZ (Atwater and others, 1995). However, newer data suggests that a magnitude of 9 or 9+ may be more likely. Because of the uncertainty, magnitudes of 8.3 and 9.0 for the CSZ were both used by the USGS (1996) in developing the PGA maps for this area. The scenario using M8.3 was weighted 0.67 and the M 9.0 was weighted 0.33 in their calculations. In general, the affect of using a M 9.0 earthquake versus the weighted scheme of the USGS would be to slightly increase the PGA on the portion of the pipeline route west of the Cascades. This new data suggesting a higher magnitude will be incorporated into seismic analysis used for the design phase of the pipeline project.

3. *<u>Estimated Peak Ground Acceleration associated with the earthquakes at the level of probability used for the assessment</u>.*

Q. Mr. Landau has testified that he believes that a deficiency of the seismic evaluation is that the applicant determined the probability level used to estimate peak ground acceleration (PGA) in the Application. Is the probability level used to estimate PGA in the Application consistent with standard practice?

A. Yes. Currently Washington regulations do not specify a probability level for seismic hazard analysis for seismic design of pipelines or related facilities beyond that outlined in the Uniform Building Code (UBC). The estimated PGA that would occur with a 10% probability within 50 years along the pipeline route presented in the application was taken directly from the USGS (1996). These USGS values were used as the basis for the 1997 National Earthquake Hazard Reduction Program (NEHRP) seismic provisions. Further, the PGA values presented in the Application were intended to provide an assessment of the relative strong ground motion hazard along the entire pipeline route. These values were not intended to be a pipeline or facility specific, design level criteria. However, the 10% within 50 years is an appropriate probability level in that it corresponds to an approximately 475 year return period—a time frame well beyond the expected life span of the project.

To get a sense of the conservative nature of this probability level, it is helpful to consider that Federal Energy Regulatory Commission (FERC) mitigation requirements for flood-related stream scour hazards for intra-state natural gas pipelines specify a recurrence interval of 100 years, *i.e.*, the PGA presented in the Application is considered over a time period *five times* as long (Cassaro 1991). In addition, this probability is the Contingency Design Earthquake (CDE) indicated by the ASCE Technical Council on Lifeline Earthquake Engineering as well as the basis for design for the Uniform Building Code (UBC). Moreover, design of the pipeline and above-ground facilities, such as the pump stations, will be done in accordance with current engineering practices and standards that consider factors other than PGA (ASCE 1984; 1997).

Q. Irrespective of the probability level used and/or magnitude, is earthquake ground shaking typically a problem for buried underground pipelines?

A. No. Strong ground shaking generally does not have a significant effect on modern, buried welded pipelines in good condition. Modern pipelines are made of ductile steel and welded with full penetration welds resulting in a structure with substantial inherent ductility. Because of this ductile behavior, buried oil and gas pipelines generally can withstand considerable soil distortion or differential displacement, and have not been affected solely by strong ground shaking. This is borne out by the lack of a single reported case of failure of ductile, full penetration welded oil or gas pipelines attributable to seismic wave propagation alone (Nyman,1996).

Q. Mr. Landau also criticizes the Application because it uses a probabilistic rather than a deterministic analyses to assess ground shaking. Why is the use of the probabilistic method appropriate in this case?

A. Both probabilistic and the deterministic methods assess the hazard of ground shaking. As discussed above, neither method is specified as being necessary for design of the pipeline itself (Nyman, 1996), except as a source of input for analysis of other seismic hazards like liquefaction or earthquake induced landslides which are addressed separately in the testimony by Conrad Felice. The only relevance of which method is preferable is for above-ground facilities. While the deterministic method is used for critical facilities like nuclear power plants and dams, the standard industry practice is to use the probabilistic method for above ground facilities associated with an oil or gas pipeline (ASCE 1984, 1997; Nyman, 1996).

4. *Faults that pose a potential surface fault rupture hazard*.

Q. How does surface fault rupture occur?

A. Surface fault rupture typically occurs associated with an earthquake of magnitude 6.0 to 6.5 and larger. These large earthquakes are generated on a fault at a depth of 5.0 km or greater. Subsurface movement on the fault propagates up the fault plane from where the earthquake was initiated (*i.e.* hypocenter) toward the ground surface (Exhibit MPM-3). The resultant surface displacement is usually preserved in the rock and Quaternary deposits at the ground surface along the source fault. The amount of surface displacement is generally correlative with the earthquake magnitude as well as surface rupture length; that is the larger the earthquake the larger and longer the surface rupture (e.g. Wells and Coppersmith, 1994). Fault rupture can occur on the fault that generated the earthquake (i.e. primary rupture) and on subsidiary faults (i.e. secondary rupture) to the source fault. Surface displacement on a secondary rupture is typically considerably less than the primary rupture.

Q. How was seismic fault rupture assessed for the Application?

A. The assessment of potential fault rupture included review of published geologic maps and seismic hazard reports. In addition, we used interpretation of aerial photographs and aerial reconnaissance to look for geologic and geomorphic evidence of displacement of the ground surface in Quaternary deposits along the mapped faults.

Q. Since Washington State does not have a regulatory definition of what type of fault poses a significant surface fault rupture hazard, how was this data assessed?

A. We considered California regulations which do have a definition of faults with relatively high potential for surface fault rupture. These “active” faults have evidence of Holocene surface displacement and are sufficiently well-defined at or near the ground surface (California Division of Mines & Geology, 1997). The Holocene is defined by California as the last 11,000 years before present. Faults are considered potentially active if there has been displacement during the Quaternary (defined as up to 1.6 million years ago) unless there is a direct geologic evidence of no displacement during the Holocene.

For the purposes of the initial hazard analysis for the Application, however, the applicant conservatively assumed that faults active within the late Quaternary period, the period from the present to approximately 700,000 years ago, posed a potential surface fault hazard to the pipeline even if there was no evidence for Holocene displacement. Where practicable, the preferred route for the pipeline avoids faults suspected or known to have surface displacement during the late Quaternary.

Q. Do all late Quaternary faults have the same potential for surface fault rupture that could impact a pipeline during a specified time frame?

A. No, all faults with evidence of displacement during late Quaternary time do not have the same hazard potential to a pipeline. For example, faults that exhibit surface rupture with recurrence intervals on the order of 10s to 100s of thousands of years pose a lesser risk than faults with recurrence intervals of hundreds to a few thousand years. In addition, the amount and type of displacement and orientation of the pipeline crossing to the fault also affect the potential for damage in the event of a surface rupture. Consequently, seismic hazard analyses conducted during the *design phase* for other pipelines, including high-pressure natural gas pipelines, have used a risk-based approach. For example, Keaton and others (1991) used an approach that considered the age of most recent displacement on a fault, the recurrence interval for surface displacement, and the proximity to population in determining what type of design treatment was used for each fault crossed by a multi-state high pressure gas pipeline. For their study, faults warranted design treatment only if: (1) the most recent displacement was 10,000 years or less in age or (2) the most recent displacement was between 10,000 and 35,000 years before present and the recurrence interval for surface displacement is less than 35,000 years warranted design treatment. The nature of the special design measures implemented at each fault that met this criteria was dependent on the level of nearby population. The 35,000-year criteria used as a cut-off date is based on regulations for siting and design of nuclear power plants that classify a fault as *capable* if it has exhibited displacement in the last 35,000 years or multiple displacements between 35,000 and 500,000 years before present. A similar approach was used for a natural gas pipeline in Texas (Keaton and others, 1995).

Q. What are typical mitigation and pipeline design measures for surface fault rupture?

A. Faults that pose a potentially significant level of risk to a pipeline should be avoided where practicable or designed for where the fault is crossed. However, numerous pipelines for crude oil, refined petroleum products, and natural gas have been constructed across active faults in the western United States. Where pipeline cross faults with a significant potential for surface rupture, it is common engineering practice to design the trench and/or pipeline to allow for potential fault rupture and associated pipe deformation without pipeline failure (Keaton and others, 1991; Nyman, 1996). Based on the information and aerial photographs reviewed during preparation of the application, the only fault identified that may be crossed by the pipeline and was considered to have a significant potential for surface fault rupture was the Saddle Mountains fault. Other faults indicated by Landau are discussed below.

Q. Mr. Landau (and Mr. Lindsey through incorporation by reference) have testified that the pipeline route crosses or approaches the surface trace of six known or suspected Quaternary-age faults or fault zones. Do these faults pose a significant surface fault rupture hazard for the proposed pipeline?

A. The faults identified by Mr. Landau do not present a surface fault rupture hazard to the pipeline, with the possible exception of the Saddle Mountains fault as indicated in the Application. Specifically:

<u>Rattlesnake Mountain</u>. This postulated fault has not been documented to have moved during the Quaternary. More importantly, because its inferred location parallels rather than crosses the proposed pipeline route and is located approximately 2 miles from the pipeline route, it does not pose a surface fault rupture hazard to the proposed pipeline.

<u>Kittitas Valley</u>. Faults identified in Kittitas Valley by Waitt (1979) that are located within the pipeline corridor are shown on Geology, Topography & Mass Wasting Hazard map pages 47, 48, and 50. These faults are inferred to be present based on the apparent offset of deposits of Thorp Gravel. These deposits have been dated at about 3.7 million years old. The actual faults have not been observed at the ground surface and there is currently no evidence of displacement of Quaternary alluvial deposits along the inferred fault traces. These deposits are inferred to be as old as 140,000 years in age (Waitt, 1979). While it is possible that there may have been displacement on the inferred faults between 700,000 and 140,000 years before present, the geologic deposits present on the ground surface of the Kittitas Valley do not allow this to be

determined. Reidel and others (1994) indicate that the most recent movement on faults in Kittitas Valley may have been during the Pleistocene (*i.e.* between 10,000 and 1.8 million years before present). However, they reference the work of Waitt (1979) summarized above and do not present any new data to support Landau's inference that displacement could be as recent as 10,000 to 13,000 years ago. Given the lack of evidence of late Quaternary surface displacement on the three faults, and geologic evidence that Holocene displacement has not occurred, these faults were not considered to pose a significant fault rupture hazard to the proposed pipeline and further investigation or other mitigation measures are not warranted.

<u>Boylston Mountain</u>. The faults shown in the application along the section of the route from the east margin of Kittitas Valley to the Columbia River (Geology, Topography & Mass Wasting Hazard maps 53 through 64) are principally based on the map of Schuster (1994), as well as the study of Geomatrix (1990) summarizing the occurrence of Quaternary faults that are potential seismic sources in this area. Schuster's map is the most recent published map of this area and reference Tolan and Reidel (1989) as a source of data used to compile the map. Consequently, Schuster's map was considered to be the definitive map for this portion of the route in the Application. In addition to Geomatrix (1990), Reidel and others (1994) provide a summary of Pleistocene and younger deformation in the Columbia Basin. Figure 8 and Tables 4 and 5 in Reidel and others (1994) paper (Exhibit MPM-4) do not include the Boylston Mountain or Ryegrass Summit areas as having documented late Quaternary displacement. They do indicate that unpublished and undocumented evidence of Quaternary faults may be present in the area of the Boylston Mountains and the Hog Ranch anticline east Boylston Mountain.

The fault indicated to be present in Section 9, T17N, R20E by Schuster (1994) was inadvertently not copied onto map page 54 of the Application. This fault is only about one mile long, is not crossed by the pipeline route or the alternative route, nor is it shown on Schuster's map as cutting Quaternary deposits (Exhibit MPM-5). The study of Bentley and Powell (1987) referenced by Landau in his testimony is not a readily available published document. It was not referenced by: (1) Tolan and Reidel (1989) as a source of data for their geologic structure map of the Columbia Basin or (2) Reidel and others (1994). In addition, it is not included in the Washington Department of Natural Resources bibliography of geologic references for Washington State (Manson, 1998). Given the short length of this minor fault, the fact that it is not crossed by the pipeline, and the lack of well documented evidence of late Quaternary surface displacement on the fault, it was not considered to pose a fault rupture hazard to the proposed pipeline and further investigation or other mitigation measures are not warranted.

The Hog Ranch anticline is crossed by the preferred and alternate pipeline routes in Sections 20 and 21 of T17N, R21E (map page 57). Tolan and Reidel (1989) do indicate that the anticline may have continued to form in the late Quaternary and two relatively short faults are present east of the anticline (Exhibit MPM-6). However, Shuster's 1994 map (Exhibit MPM-5), does not indicate these faults are present in the area shown on map pages 57 through 59. In addition, Tolan and Reidel (1989) do not indicate these faults are Quaternary faults. Review of aerial photographs obtained for the Application did not identify obvious evidence of late Quaternary surface displacement along the mapped location on these faults. The study of Bentley and Powell (1987) referenced in the Landau testimony as indicating Quaternary displacement is not a readily available published document as outlined above.

Based on the information outlined above, these faults, if present, are most likely minor secondary faults associated with the anticline and are not capable of generating significant, primary surface rupture associated with an earthquake. Given the relatively short lengths of the faults indicated by Tolan and Reidel (1989) and the lack of well documented evidence of late Quaternary surface displacement on the faults, these were not considered to pose a significant fault rupture hazard to the proposed pipeline. However, in light of the testimony, the location and nature of these faults will be assessed in the field and design measures will be implemented if warranted.

Wanapum/Sentinel Gap. As indicated in the application, the Frenchman Hills and Saddle Mountains faults are considered to be potential sources of future moderate to large earthquakes and associated surface fault rupture. However, cross faults at Wanapum and Sentinel Gaps, if present, do not necessarily pose a significant surface fault rupture hazard to the proposed pipeline. The presence of cross faults is inferred, but these faults have not been documented by direct evidence of displacement of late Quaternary age deposits. It is possible that the east-west trending Saddle Mountains fault and the associated anticlinal ridge south of the fault bend to a more northwest trend west of the Columbia River without a cross fault present beneath the Columbia River. Given that displacement on the Saddle Mountains fault was initiated as much as 17 million years ago and most (estimated to be as much as 80%) of the displacement and associated folding was completed by 10.5 million years ago (Reidel, 1984), it is also possible that if cross faults are actually present these faults are inactive.

As shown on the maps of Reidel (1988), Tolan and Reidel (1989), Reidel and Fecht (1994), the inferred extent of the postulated faults do not extend beneath Wanapum Dam or the

Vantage crossing alternative route (Exhibits MPM- 6, 7 & 8). In addition, Galster (1989) does not indicate the presence of a fault in Miocene age basalt extending into the overlying Quaternary deposits in the vicinity of Wanapum Dam (Exhibit MPM-9). If the inferred faults are present and are fold segment boundaries as indicated by Landau, then these are probably located at the end of future potential fault rupture segments on the main faults. Fault rupture data for historical earthquakes in the western United States, as well as world-wide data, indicate that the amount of primary surface rupture decreases towards the end of the rupture zone. Consequently, if surface rupture were to occur on one of these relatively short cross faults, the likely amount of rupture would be relatively minor. Given (1) the short length and secondary nature of these inferred faults, (2) the fact that the mapped traces of the inferred faults are not crossed by either of the alternative pipeline routes, and (3) the lack of well documented evidence of late Quaternary surface displacement on the faults, these were not considered to pose a fault rupture hazard to the proposed pipeline and further investigation or other mitigation measures are not warranted.

Saddle Mountains Fault. As indicated in the application, the Saddle Mountains fault is considered to be a potential source of future large to major earthquakes and associated surface fault rupture. The portion of the fault with documented late Pleistocene and Holocene displacement is located approximately 8 ½ miles west of where the pipeline route crosses the inferred eastern extent of the fault as mapped by Reidel and Fecht (1994) (Exhibit MPM-10). Reidel (1988) did not show this inferred fault crossing the pipeline route on his more detailed map of the Saddle Mountains (Exhibit MPM-11). As currently mapped, the inferred portion of the fault crossed by the pipeline does not displace the pre-Quaternary Ringold Formation or late Quaternary loess and alluvial deposits. The feature shown on map atlas page 82 is a monocline in the Miocene age basalt as mapped by Grolier and Bingham (1971), Reidel (1988), and Reidel and Fecht (1994).

Q. The Application states that trenching of the Saddle Mountain portion of the pipeline will be performed to allow a qualified geologist to inspect for evidence of fault or deformed soils. Several witnesses have expressed concern that this assessment will not take place until the pipeline is already under construction; could you respond?

A. The existence of a concealed fault crossing the pipeline route near Saddle Mountain is inferred rather than documented. In the Application, it was intended that a special design for the fault crossing would be developed based on the amount of surface rupture that has occurred in a single rupture event on the Saddle Mountains fault west of the crossing. This design would be implemented if it is determined that a near surface fault is actually present at the inferred crossing. With appropriate planning, this portion of the trench could be excavated with sufficient time in advance of installation of this portion of the pipeline to allow a determination of whether a fault is present, and if so, implement the design.

However, in light of Mr. Landau's testimony, OPL will conduct the fault study by trenching prior to design and incorporate the results into the design prior to construction. Even if such a fault is established during the study, this section of the pipeline would be designed for crossing a reverse-slip fault consistent with standard engineering practice. Design measures for mitigation of fault rupture hazard includes crossing the fault at a right angle, modifying the trench configuration, extending the length of pipeline between anchor points, and using a specific type of backfill material (Nyman, 1996).

EROSION

Q. How was erosion potential along the pipeline route identified in the Application?

A. The intent of the Application was to identify areas with a potential for erosion that would warrant mitigation measures during construction and operation. It was not intended to be a quantitative assessment, nor is one necessary for the purpose of the Application. Soil erosion potential along the alignment was classified as low, medium or high in accordance with the published assessments by the Natural Resource Conservation Service (NRCS) and the Washington State Department of Natural Resources (DNR). As shown on the Soil Type and Erosion Hazard Maps in Appendix B, soil types consistent with NRCS and DNR classifications were identified along the entire alignment and classified as to their erosion potential as determined and reported in the surveys published by these agencies. This data was supplemented and confirmed with interpretations from aerial photographs. This process is an accepted method as outlined by DNR for conducting watershed analyses.

Q. The STEH maps classify erosion potential as low (no shading), moderate (shaded gray) and high (shaded black). Landau expresses confusion as to how these classifications made. Could you explain this in more detail?

A. As described above, the classification of erosion potential was based on NRCS and DNR reported assessments and supplemented with a review of aerial photographs. Because of the different classifications used by NRCS and DNR, the classifications were presented in the Application as follows: (1) slight or low = low; (2) moderate = moderate; and (3) high, severe or very severe = high.

Q. How does OPL intend to mitigate the potential for erosion during construction, operation and maintenance of the pipeline?

A. OPL recognizes that the construction of the pipeline will increase the potential for soil erosion, particularly during construction. In recognition of this fact, OPL has committed to develop an aggressive Stormwater Pollution Prevention (SWPP) plan to minimize and control erosion to protect public resources during and following the construction of the pipeline. Before implementation, a plan for Erosion and Sediment Control (ESC) will be prepared and submitted for review. The objective of this plan will be to control the short term and long term erosion potential to mitigate sediment delivery to a level of non-significance on public resources including fish habitat and water quality.

During the operating life of the pipeline, periodic maintenance and inspections will be performed by ground vehicles and aerial reconnaissance. Therefore, following DNR recommendations, traffic along the corridor is considered none and the road use category as non-use. During operating and maintenance activities the primary erosion control method will be re-vegetation and maintenance of vegetation to minimize exposure and prevent soil erosion. Secondary measures that may be used if warranted include, hay bales, silt fences, etc. The combination of limited use and active control measures will reduce erosion potential to below prior construction background levels.

Q. Mr. Landau expresses some concerns about some of the details of the Stormwater Pollution and Prevention (SWPP) Plan. Could you provide more information?

A. The SWPP plan intended to reduce impacts from erosion and sedimentation will be developed for construction and submitted at least 60 days prior to beginning construction. The SWPP plan will consist of two main parts: (1) an Erosion and Sediment Control Plan (ESC), the part of the plan relevant to the control of erosion; and (2) Control for Pollutants other than Sediment. As

Landau suggests, the ESC is analogous to the Stormwater Site Plan described in the Department of Ecology's (DOE) Stormwater Management Manual. Like the Stormwater Site Plan, OPL's ESC will meet the "Minimum Requirements" described in Chapter I-2 of the Stormwater management Manual (as revised beginning in January 1999). As set forth by DOE, these requirements are satisfied by application of BMPs (Ecology 1992, p. I-01-8). As Landau points out, it is anticipated that the revisions to Chapter 2 of the Stormwater Management Manual will address potential problems east of the Cascade divide. In the event the revisions to the DOE Manual for some reason neglect to address these issues, OPL will nonetheless employ BMP's appropriate to address erosion and sedimentation issues specific to the east side of the Cascades.

Q. Mr. Landau observes that the Universal Soil Loss Equation (USLE) could also be used to estimate the effects of sheet and rill erosion. Is this necessary?

A. No. The Application quantifies erosion using techniques recognized by Natural Resource Conservation Service and the Washington State Department of Natural Resources. USLE is simply another method of classifying erosion.

Q. As part of the design phase, does Olympic intend to review any additional information regarding the potential for erosion?

A. OPL's intent is to be thorough, therefore, in addition to the information already collected and reviewed; OPL will review all relevant information. This includes for example, the watershed analyses identified in the testimony of Mr. Conrad Felice regarding mass wasting.

Q. Mr. Landau suggestions that erosion should be monitored consistent with BMPs during construction and after the pipeline commences operation. Will this be done?

A. Yes. Monitoring will take place in accordance with BMPs.

DATED this 25th day of March, 1999.

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Mark P. Molinari

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